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Submarine development in the 20th century

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Admiral Wood explains the evolution of British and Australian submarines during the 20th century.

Key words: submarines; 20th century evolution; Australia; Britain, Germany.

Britain and Australia have been involved in the submarine business since it all began in 1901 and my purpose is to trace the development of their participation in underwater warfare during the last century.

To put things into perspective, though, we need to go back several centuries during which quite a few embryo scientists and engineers tried their hand at designing a vessel that could dive and re-surface after attacking enemy sailing ships in harbour. Their efforts frequently met with disaster, but many lessons were learnt in the process, especially during the North American conflicts of the 17th and 18th centuries. Much later, in 1879, an English country parson called George Garrett produced a 30-ton beast, which he named *Resurgam*. His design included one of the first examples of what became known as a conning tower. Unfortunately, *Resurgam* foundered under tow and sank, but she had achieved submerged propulsion for 4 hours at 2-3 knots using a semi-closed-cycle steam engine. So the race was on for a credible and controllable design.

Holland Submarines

An intrepid Irish-American inventor, John Philip Holland, came up with a workable submarine solution. By 1895, Holland was confident enough to tender his design for consideration by a number of navies that were interested in underwater warfare. The Americans, in particular, became convinced of the need. But he met outright opposition in London from some members of the Admiralty Board. One senior admiral sourly stated that it was not an occupation for 'gentlemen', and went on to suggest that, in wartime, the crews of captured submarines should be treated as pirates and hanged!

So Mr Holland went back to America where he developed his design to an advanced and very successful degree. The Holland-class submarine emerged and was chosen in 1900 by the British (who ordered five) and American governments to be their first true submersible warship. Her vital statistics were: length 54 feet; beam 10 feet; surface displacement 64 tons; and a crew of 7. Her power for propulsion and battery re-charging was provided by a 45 horse-power petrol engine, giving about 8 knots on the surface, and a 50 horse-power electric motor, which drove her at up to 5 knots dived. Her armament was a single, pre-loaded, 18-inch diameter torpedo tube, with two reload torpedoes behind – stowed internally up forward. Her maximum safe diving depth was 100 feet, beyond which it was calculated that her pressure hull would collapse.

Conditions on board were dire once the hatch was shut. The Holland was almost impossibly cramped; much of the machinery was inaccessible; there was virtually no stowage space for personal gear or belongings; there were no toilet facilities, apart from a bucket up forward; petrol and chlorine fumes, coupled with severely reduced oxygen, led to foul atmospheric conditions and sickness; and there was a constant, serious threat of a petrol explosion. There were no proper lookout facilities. Crude control mechanisms frequently resulted in involuntary porpoising, leading to either inadvertent surfacing or dangerous depth excursions. It is a wonder that they attracted any volunteers at all, but they did, apparently without much difficulty.

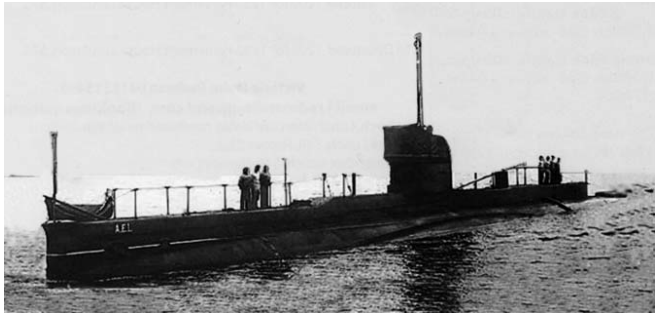
British Submarines of Classes A to V

The five Holland boats were replaced alphabetically by the A, B and C classes, each of six to eight boats, and each class progressively larger than its predecessor. They were gradually fitted with two or more torpedo tubes, but they were all still powered by dangerous petrol engines. The first A boat in 1904 looked more like a self-propelled surfboard than a 70-foot hull containing 10 or more souls beneath the surface. Tragically, she succumbed to an internal explosion, a fate which overtook several others in those early years.

It was not until the D class of 1909 that diesel fuel (less volatile and much safer) was introduced, along with external ballast tanks and many other safety and control innovations. Meanwhile, in other countries such as France and Germany, new and more effective submarine designs were also being developed. In 1906, the German government ordered 'Unterseeboot Eins' (U Boat No. 1) whose successors were to bring Britain almost to its knees in the latter stages of World War I by devastating its merchant marine trade. Britain herself had 55 submarines in service when the Great War started in 1914 – mostly of the C and D classes. But already in early production were the famous E class of which 57 were to be built during that war.

In 1913, *AE1* became the very first Australian submarine to be commissioned. She and her sister submarine, *AE2*, were the only two built specifically for the Royal Australian Navy (RAN) at that time. They were part-Royal Navy and part-RAN manned and they sailed, with

escorts, from Britain to Sydney via the Suez Canal and India in March 1914 – an amazing feat for that era. Sadly, before the end of 1914, *AE1* was lost with all hands in never-explained circumstances near the King George's Channel off Rabaul in New Britain after patrolling with the destroyer HMAS *Parramatta* in search of a German cruiser squadron which had last been seen in the New Guinea area.



The Australian E-class submarine, *AE1*, in 1914
[Photo: Commander J D Foster OAM RAN (Ret'd)]

A few months later, *AE2* went to war off Gallipoli and, on 25 April 1915, became the first submarine to successfully transit the Dardanelles into the Sea of Marmara. Her subsequent sinking by a Turkish gunboat was a travesty of fortune and her commander and crew were inexplicably denied honours which they undoubtedly earned and richly deserved. *AE2*'s was a truly heroic story and her exploits are only now belatedly being recognised.

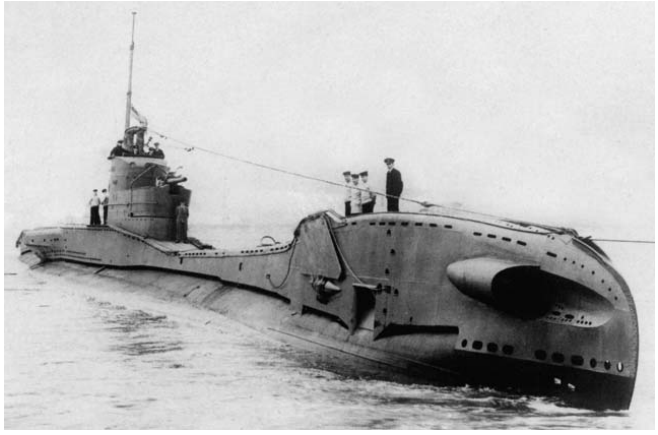
During and after the Great War, the alphabet of classes went on through the Fs, Gs and Hs. The 40 H-class boats became workhorses capable of unrestricted worldwide deployment. Some conducted blockade and reconnaissance patrols in the North Sea off Denmark and Holland in both world wars.

Next came the J class of seven boats, of which six were transferred to Australia in the early 1920s so that the RAN could start its own submarine service. They were based in Sydney, at Garden Island, Cockatoo Island, and alongside the first Australian submarine depot ship, HMAS *Platypus,* which frequently anchored in Watsons Bay. They served through the 1920s, but they were found difficult to man and maintain. They also fell foul of post-war weariness and lack of enthusiasm, such that the small RAN fleet had difficulty in employing them for surface-ship training purposes. They never came to fruition as a positive arm of the navy and were scrapped in the early 1930s. An important side benefit, however, was that quite a large number of fully-trained RAN submariners stayed on to transfer their valuable skills during the run up to World War II, and specialist expertise was thereby retained for the future. Subsequently, many Australian submariners served with distinction in Royal Navy flotillas during World War II.

Meanwhile, as the Great War progressed, their lordships at the Admiralty had a number of rushes of blood to the head concerning submarine design. One of their least sensible ideas was to develop an entirely new concept whereby fast submarines on the surface would keep up with the battle fleet using steam propulsion. The idea was that they would dive ahead of the surface ships once an enemy was sighted and deliver a series of torpedo attacks for the battleships to mop up. Accordingly, the infamous 24-knot K class was conceived in 1915, and nearly 19 boats were built and completed by the end of the war. Three-times larger than any other submarine of the day, and with bows like a destroyer, they had two powerful steam turbines, two oil-fired boilers and two funnels. All this highly complicated and manpower-intensive machinery took ages to shut down, and prevented diving for between 5 and 10 highly-vulnerable minutes whilst the funnels came down and steam systems drained into internal tanks, thereby immediately affecting the diving trim as well as dangerously raising the onboard tempeature. Worst of all, their handling characteristics were extremely poor and they were no faster underwater than any other submarine. Indeed, with their size, they were actually somewhat slower. Their dreadful tally of major accidents eventually reached 16, from which eight finished on the seabed, and the class was finally scrapped in 1932 after over 300 men had been lost – not one of them to enemy action.

The Submarine Service itself entered 'cloud-cuckoo land' during the inter-war years, with a number of eccentric and plainly unsuitable design flights of fancy such as, for example, the M class. There were three of these boats converted from K class hulls in the mid-1930s. One had a 12-inch battleship gun mounted on the fore casing forward of the bridge. It was fixed ahead only, because the recoil could have capsized the boat if fired to one side of the fore and aft line. As it was, the recoil propelled the entire 1600-ton submarine backwards at a rate of knots on discharge! The second tried carrying such a vast number of mines that she went to the bottom and stayed there. And the third was configured for a small seaplane with watertight hangar and catapult on the fore casing. Tragically, she dived with her hangar doors open – with predictable results.

Fortunately, in the later 1930s as war clouds were gathering, submarine design commonsense finally delivered four successively improved classes of British submarine to the drawing board. These were the S, T, U, and V classes, of which the first three formed the bulk of well over 100 submarines to take the brunt of hostilities to come. The S boats were workhorses, as the old H boats had been at the end of the Great War, whilst the bigger



HMS *Thorn*, an early T-class long-range submarine, in 1941
[Photo: Royal Navy Submarine Museum]

and newer T boats were found to be an exceptionally good design in terms of capability, endurance and adaptability for a variety of roles.

German U-Boats

An aspect of German U-boat development in World War II that is not widely understood was the high quality of their crews, scientists, design engineers, manufacturing processes and professional naval training. Pre-war, and certainly during the first half of the war itself, they were far in advance of the Allied navies in terms of innovation, operational planning and execution. This is why they gave us such a torrid time and towards the end nearly brought Britain to its knees yet again, having sunk over 14 million tons of vital merchant shipping – nearly 3000 vessels in all.

But they suffered dreadful losses. They built well over a thousand Type VII and Type IX U-boats and they lost 784 of them – 68 per cent. Of 41,000 men recruited into the U-boat Arm, no less than 28,000 (or 69 per cent) lost their lives, with another 5000 being taken prisoner – in total, nearly three-quarters of their men lost from the service.

Yet, despite that terrible toll, and the ever-increasing Allied destruction of their strategic manufacturing capability, they still managed to build and launch submarines of superb quality which were a generation ahead of their time. Had those boats, especially the new Type XXI and Type XXIII, been available at the height of the Battle of the Atlantic, they could well have gained the upper hand.

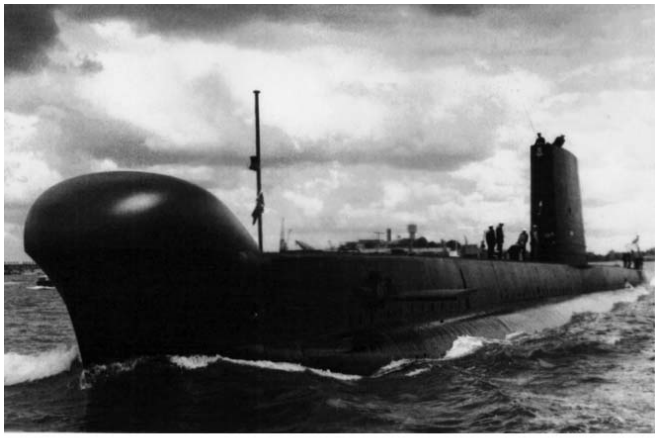
In 1945 when the Allies gained access to these amazing submarines, America, Russia, Britain and France all grabbed a few to discover their secrets. Not only did that result in major design changes to their own national next-generation diesel-electric driven submarines, but it accelerated the need for a fundamental shift in propulsion technology to counter the future threat.

Australian Submarines

Meanwhile, in Australia, the Pacific campaigns of World War II led to the creation at Fremantle of the largest and most concentrated submarine base in the Southern Hemisphere, from which hundreds of United States, British and Dutch submarine patrols set off towards Japanese-occupied islands and the South China Sea during 1944 and 1945.

After victory over Japan, these Fremantle-based submarines dispersed back to their national home bases with the exception of the depot ship, HMS *Adamant*, and a flotilla of eight British T boats which sailed to Sydney. From 1949 to 1967 under a government-to-government agreement, there was continuous provision of three or four Royal Navy boats of the T or newer A classes based in Sydney to assist the RAN with anti-submarine training, although they remained Royal Navy assets. They were berthed at HMAS *Penguin*, which provided accommodation, victualling, engine-room, electrical and battery maintenance, workshop support and weapon servicing ashore.

The setting up of the first Australian shore-based submarine squadron in Sydney followed in 1967 when the Australian navy took delivery of HMAS *Oxley,* the first of six new Oberon-class submarines built in Scotland. *Oxley's* arrival marked the opening of the new HMAS *Platypus* submarine base at Neutral Bay. These modern diesel-electric powered submarines had been developed in the United Kingdom for the Royal Navy in the early 1960s and were a direct legacy of World War II German submarine innovation. The O boat's resultant reputation as the quietest operational diesel-electric driven submarine in the world was fully justified, and a series of substantial update programmes maintained and even improved upon this achievement, whilst increasing their operational service by many years. The six Australian O boats were skilfully manned, operated and commanded, and they deservedly earned admiration and commendations for their performance over the next 20 years.



An Australian Oberon-class diesel-electric powered submarine
[Photo: Department of Defence]

One of the squadron's greatest successes was the introduction of a new weapons system update developed in Australia in the late 1970s which greatly improved performance and ensured O-boat supremacy as the best non-nuclear submarine in the world. The new designs were eagerly purchased by other O-class nations, including the Royal Navy. It was perhaps this, as much as anything else, that confirmed the RAN's readiness and ability to proceed with a modern successor when the time came – and that, of course, was to be the Collins class: the fifth-generation Australian submarine programme. HMAS *Collins*, displacing some 3000 tonnes, was the largest conventionally-powered submarine of her day when commissioned in 1996.

HMAS *Collins*, the first of six Australian Collins-class diesel-electric powered submarines, in 1996
[Photo: Department of Defence]

The RAN of today is capable of operating modern submarines with panache, skill and technical ability. For all its current difficulties, the Collins-class is at the peak of conventional submarine technical and operational achievement and the people who man them are similarly endowed. If the necessary national investments in schooling, support and commercial cross-fertilisation to achieve adequate trained manpower were in place, the RAN's transition to nuclear-powered variants would, in my view, be perfectly feasible.

Nuclear-powered Submarines

From the mid-1950s to the late-1980s, nuclear-powered submarines transformed maritime operations and changed many nations' naval policies very considerably. The primary task of World War II conventional submarines had been the destruction of enemy naval and merchant shipping. But the post-war political and military situation changed dramatically with the emerging power groupings of the Warsaw Pact and NATO[1], the threat of a nuclear exchange in the Cold War and the imminence of nuclear propulsion being introduced at sea, in what became a hectic race for East/West dominance. The submarine's prime underwater warfare tasks now became surveillance and intelligence-gathering to enable threat assessment of the opposition, and ultimately preparation for the destruction of its surface warships and other submarines.

When hunting submarines, the most effective counter to a modern, fast, stealthy and deep-diving opponent is another submarine which is capable of detecting and stalking the other from the deep and then, if necessary, sinking it using sophisticated weapons. And they need to be nuclear-powered to do all that. The concept led the nuclear-powered attack submarines (SSNs) to become known as 'hunter-killers', which described their primary role quite well.

The Royal Navy's first nuclear-powered attack submarine was HMS *Dreadnought*, commissioned in 1963. Her distinctive whale-shaped hull gave reduced drag and emphasised speed rather than stealth. She was quite small – at 3000 tons, only about twice the size of contemporary diesel boats. But for her complement of 113 officers and men, it was a completely new ball game, necessitating comprehensively re-organised recruitment, training and re-training necessary to prepare the crews and shore bases for the operation and support of these revolutionary new boats. Nor was it simply a question of learning. The unique qualities of life on board required personnel of proven ability and leadership, capable of withstanding long periods of time underwater.

The whole point of these boats was that they would submerge as soon as they left their base and, if necessary, remain dived for the duration of their operational patrol until surfacing outside their home base once again. Crews might go for weeks without seeing daylight or having any contact with the outside world,

HMS *Dreadnought*, Britain's first nuclear-powered attack submarine (SSN 01) in 1963
[Photo: Royal Navy Submarine Museum]

other than by receiving broadcast messages from shore – and then only by undetectable communication techniques well below the surface. The boats would never themselves transmit except in the direst of circumstances because of the possibility of interception and giving away their presence. Most people on board would not have the slightest idea of their whereabouts, the time zone they were in, or even whether it was night or day.

Two- or three-month, and even longer, dived patrols were perfectly feasible, so aspects of crew welfare necessarily became a priority in both selection and training. Prospective crews needed careful screening for temperament, intelligence and stamina, as well as operational competence. Social misfits in particular could not be countenanced and were rejected. So this was the scene as 30 years of Cold War operations began in earnest, and it proved to be a demanding tactical training ground.

Dreadnought and her sisters, *Valiant* and *Warspite*, were followed by a succession of evermore sophisticated and costly, but increasingly effective SSNs. The initial interim class of three C boats *Churchill*, *Conqueror* and *Courageous*, was followed from 1973 onwards by the first of 14 larger, deeper-diving SSNs of the Swiftsure and Trafalgar classes, which took the brunt of Cold War operations during their most intensive period. To achieve the required operational capability, evermore complex detection, analysis and weapon-system technologies had to be developed. Concurrently, in close co-operation with our American allies, surveillance patrols were conducted against Soviet surface and submarine activity in the far reaches of the North Atlantic and elsewhere, including under the Arctic ice, so as to constantly assess the growing maritime threat.

To illustrate the scale of that threat, by the mid-1980s, the Soviet Northern Fleet alone was operating over 130 nuclear-powered and 65 diesel-electric powered submarines in the Atlantic and its northern approaches, and every three years or so they deployed progressively more capable variants. They had three other major fleets in which the same escalation was evident in the Black Sea,

[1]North Atlantic Treaty Organisation

the Mediterranean and the Pacific. For submariners, it was a huge underwater tug-of-war which thankfully remained cold rather than hot, but which threatened 'global warming' on occasions! It was certainly never dull and some fairly close-quarter situations did develop from time to time. It was this eyeball-to-eyeball confrontation that defined the need for highly sustainable power and long endurance underwater, together with increasing stealth and reduced vulnerability to counter detection by an opponent – some of the classic attributes offered by nuclear-powered boats.

So far, I have only been describing nuclear-powered submarines of the attack variety (SSNs). There are others which, as well as being nuclear-powered, carry ballistic missiles with nuclear warheads. They are large submarines, known as SSBNs, which belong to the deterrent force and which are quite differently employed from the others. They must remain undetected and at constant alert and readiness at all times. The Royal Navy built four of these Resolution-class ballistic missile-firing submarines which saw uninterrupted and undetected service as Britain's national deterrent for nearly thirty years from 1968 to 1997. They were boats of about 8000 tons displacement and they were armed with torpedoes like the hunters, but also with the weapons of their primary purpose – 16 Polaris ballistic missiles, which could be launched to a range of 2500 nautical miles.

After the Resolution-class SSBNs paid off, they were replaced in the late 1990s by today's even bigger and more powerful Vanguard-class SSBNs. Truly leviathans of the deep, they weigh in at 17,000 tons and are armed with 16 Trident ballistic missiles having a range of 6500 nautical miles. They can roam with relative impunity throughout the Atlantic or Indian Oceans and still remain within range of the majority of their possible targets.

Coming right up-to-date, the Royal Navy now also has a new attack SSN of the Astute class. HMS *Astute*, herself, arrived on the scene last year. Larger and many times more capable than any of her predecessors, an Astute-class boat costs a cool £1.5 billion (about AU$2 billion) per copy. Over 100 metres in length and with a 50 per cent greater weapon load than any previous SSN, her dived displacement is nearly 9000 tons and she can remain at sea under full-power conditions, if needed, for her entire 25-year life, because there is no need to refuel her reactor at all in between times – thus obviating the need for lengthy and expensive refuelling refits. This is just one feature of this remarkable submarine, but it is a huge one in terms of the saving of through-life costs. She has a crew of only 98 as compared to 118 in the Trafalgar class – another considerable saving.

HMS *Vanguard*, a British ballistic-missile firing, nuclear-powered submarine (SSBN 05)
[Photo: Royal Navy Submarine Museum]

Conclusion

This has been a very brief canter over a century's-worth of submarine development history, with just a snapshot from our two nations. Time has not allowed more than passing reference to the achievements of other world navies whose experience and capabilities have also affected, and in some cases overtaken, the progress of underwater warfare in the 20th century. So here we are in the 21st, and history as we all know is apt to reoccur – indeed, those who fail to learn its lessons are destined to repeat it. I suggest that lessons from the last century merit serious contemplation and review, because the submarine's influence as an instrument of sea power projection appears more probable today than it has ever been before.

The Author: Chris Wood entered the Royal Navy as a seaman officer cadet in 1954 and commenced preliminary submarine service in 1956, before specialising in 1958. He served in Australia, New Zealand, and the Far East between 1958 and 1964 and was based for some time in Sydney with the Royal Navy's 4th Submarine Squadron. He later served in four different classes of diesel-electric submarine, operating in the North Atlantic, Baltic, Mediterranean and South Atlantic oceans before qualifying for command. In the United Kingdom and the Far East, he commanded diesel-electric submarines prior to nuclear training in 1970. From 1970 to 1973, he commanded the nuclear-powered attack submarine, HMS *Warspite*. From 1974 to 1982, he was appointed to the staff of Flag Officer Submarines and the Ministry of Defence in London as a specialist in operational requirements. Thereafter, he held senior appointments in underwater warfare research and development. Promoted rear admiral in 1985, he served in two further appointments in London, before retiring from the Navy in 1991 after 37 years' service. He was appointed a Companion of the Order of the Bath. In 2004, he emigrated to Australia with his Australian wife, Margot. They live in Sydney. [Photo of Admiral Wood: Colonel J. M. Hutcheson, MC]